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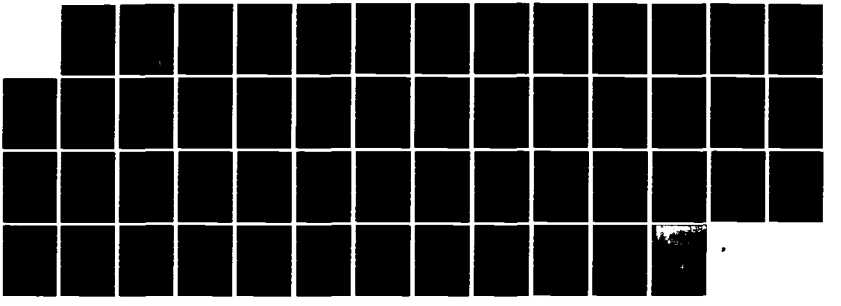

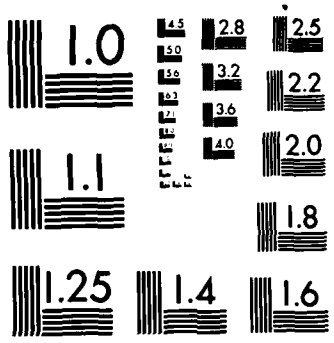


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MGA-5181-PRO

VOLUME I

# OPTIMIZATION OF SKILL RETENTION IN THE U.S. ARMY THROUGH INITIAL TRAINING ANALYSIS AND DESIGN:

FINAL REPORT

Project Director:
Kay E. Rigg

May 1983

McFann-Gray & Associates, Inc.
2100 Garden Road, Suite J
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408-373-1111



SPONSORED BY THE U.S. ARMY TRAINING BOARD
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## REPORT DOCUMENTATION PAGE

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| | |
|---|---|
| 1. REPORT NUMBER: 0005 | 2. GOVT ACCESSION NO.: AD-A132 188 |
| 3. RECIPIENT'S CATALOG NUMBER: | |
| 4. TITLE (and Subtitle): Optimization of Skill Retention in the U.S. Army Through Initial Training Analysis and Design | 5. TYPE OF REPORT & PERIOD COVERED: Technical, March 1982 - April 1983 |
| | 6. PERFORMING ORG. REPORT NUMBER: MGA-5181-PRO |
| 7. AUTHOR(s): Kay E. Rigg | 8. CONTRACT OR GRANT NUMBER(s): DABT60-82-Q-0022 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS: McFann-Gray & Associates, Inc., 2100 Garden Road - Suite J, Monterey, California 93940 | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Army Training Board, ATTN: ATTG-ATB-TA (Major Nichol), Fort Eustis, VA 23604 | 12. REPORT DATE: May 1983 |
| | 13. NUMBER OF PAGES: 695 |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) | 15. SECURITY CLASS. (of this report): Unclassified |
| | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Common Tasks
Individual Skills
Refresher Training
Retention
Skill Sustainment

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report summarizes the results of a test of the capability of MGA software to estimate training and retention outcomes from a small sample of first trial data. There were three test objectives: 1) test the ability of STAR® software to estimate soldier end-of-course scores; 2) to test the ability of STAR® to forecast skill decay over time; and, 3) to determine the frequency of training required to sustain skill.

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20. Continued

The Army Training Board (ATB) and the Infantry School (USAIS) selected 114 CMF tasks for this test. All training and data collection were conducted by officers and NCOs from TRADOC and USAIS. Data analysis was performed by MGA staff members.

Sixty-eight soldiers were selected at random from two new manning companies to take part in this test. Participants received standard POI task information and demonstration, and were then tested on the task. First trial data were recorded by the task force and transmitted to MGA for analysis.

MGA produced the following estimates based on this first trial data: training criterion; the minimum End-of-Course scores; the retention interval in weeks for a decay to 60% correct performance.

The soldiers were trained to criterion, returned to the POI, and then retested on the tasks the day before POI refresher training.

ATB selected 40 tasks for in-unit testing. Eighteen tasks were tested at Fort Campbell after a nineteen week interval and twenty-two tasks were tested at Fort Lewis after a twenty-one week interval.

The major findings of this operational test were:

- The average MGA end-of-course estimates were within two percentage points of the average observed end-of-course scores for tasks trained to criterion.
- MGA software was calibrated to provide retention estimates at two levels of confidence. At the 99% level of confidence it was expected that 99% of the observed task performance data would exceed MGA estimates. Thirty-eight out of forty, or 95% of the tasks met this expectation. At the 80% confidence level it was expected that 80% of the observed task performance data would exceed the MGA estimates. Thirty-five out of forty, or 87.5% of the tasks met this expectation.
- For these first trial data, MGA software predicts that training to criterion one GO should be sufficient exposure to sustain skill. Ninety-one percent (91%) of the Fort Lewis soldiers scored two consecutive perfect trials after meeting criterion one GO. These soldiers took 72% fewer sustainment training trials to reach criterion that they had required to learn the same tasks in the training base.

MGA-5131-PRO

VOLUME I

# OPTIMIZATION OF SKILL RETENTION IN THE U.S. ARMY THROUGH INITIAL TRAINING ANALYSIS AND DESIGN:

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The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

## BRIEF

Objective:

The objective of this effort was to perform an operational test of the capability of MGA Skill Training and Retention (STAR©) software to estimate training and retention outcomes based on a small sample of first trial data. This objective was threefold: 1) To test the ability of STAR© software to estimate soldier proficiency at end-of-course; 2) to test the ability of STAR© to forecast soldier skill decay over time; and, 3) to determine the frequency of training required to sustain soldier skills.

Procedures:

The Army Training Board (ATB) and the Infantry School (USAIS) jointly selected 114 CMF 11 and soldier's common tasks for this test. MGA staff produced performance measures that were reviewed by USAIS staff and used for testing and training the tasks. All training and data collection were conducted by a task force of officers and NCOs from TRADOC and USAIS. Data analysis was performed by MGA staff members.

Soldiers from platoons of two new manning training companies participated in this effort. Participants received standard POI task information and demonstration and were then tested on the task. First trial data were recorded by the task force and transmitted to MGA for analysis.

STAR© analysis produced the following estimates based on this first trial task data:

- SSE training criterion: the number of successively correct (GO) trials the soldiers were required to perform in training so that 80% had stopped making errors. (USAIS selected this criterion.)

- STAR© estimate of the minimum End-of-Course performance.

- STAR© estimate of the retention interval in weeks for a decay to 60% correct performance.

The soldiers were trained to criterion, returned to the POI and then retested on the tasks the day before POI refresher training.

ATB selected 40 tasks for in-unit testing. Eighteen (18) tasks were tested at Fort Campbell after a 19-week interval and 22 tasks were tested at Fort Lewis after a 21-week interval. Since many of the tasks had retention intervals that exceeded these periods, the STAR© retention performance estimates would have been low and were adjusted accordingly. An additional adjustment was made in the field to account for training that had been conducted in the units. In all cases, the estimates were raised prior to testing. At Fort Campbell, the soldiers were merely tested on the tasks. The Fort Lewis soldiers, on the other hand, were tested and then trained to one perfect GO. They were then given two additional trials to determine if the first GO trial was due to chance.

Findings:

1. The average STAR© end-of-course estimates were within two percentage points of the average observed end-of-course scores for tasks trained to criterion.

2. STAR© was calibrated to provide retention estimates at two levels of confidence. At the 99% level of confidence, it was expected that 99% of the observed task performance data would exceed the STAR© estimates. Thirty-eight (38) out of 40, or 95%, of the tasks met this expectation. At the 80% confidence level, it was expected that 80% of the observed task performance data would exceed the STAR© estimates. Thirty-five (35) out of 40, or 87.5%, of the tasks met this expectation.

3. For these first trial data, STAR© predicts that training to criterion one GO should be sufficient exposure to sustain skill level. Ninety-one (91) percent of the Fort Lewis soldiers scored two consecutive perfect trials after meeting criterion one GO. These soldiers took 72% fewer sustainment training trials to reach criterion than they had required to learn the same tasks in the training base.

Use of Findings:

Criterion: Training to the STAR© accuracy criterion yields predetermined predictable performance, making it possible to trade off performance versus training cost.

End-of-Course Estimates: The ability to predict EOC performance on the basis of a small sample of first trial data makes it possible to audit, refine and develop training to meet predetermined performance objectives in the training base.

Sustainment Cycles: Using the STAR© calibration feature, it is possible to generate a variety of skill sustainment strategies and plan individual skill sustainment training in active and reserve units.

Refresher Training Model: Training to criterion one GO after the prescribed sustainment interval provides sufficient exposure to retrain soldiers in units. This retraining represents a significant saving over initial training.

Initial Individual Skill Training In-Units: All of the procedures used in this effort can be transported to active and reserve units for initial individual skill training.

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## EXECUTIVE SUMMARY

### OBJECTIVES

The goal of this mutual effort between the Army Training Board (ATB) and McFann, Gray & Associates, Inc., (MGA) was to perform an operational test of the MGA Skill Training and Retention (STAR©) software to determine if it can be developed into a useable and effective tool that can assist field commanders in attaining and sustaining high levels of soldier individual skill performance. This test had three objectives: 1) To test the ability of STAR© software to estimate how proficient soldiers would be after training in the training base; 2) to test the ability of STAR© to predict the decay in individual skill performance over time in active units; and, 3) to determine what is required to retrain the individual to the desired proficiency in active units.

### PROCEDURES

Soldiers from platoons of two new manning training companies participated in this effort. Participants received standard POI task information and demonstration and were then tested on the task. First trial data were recorded by the task force and transmitted to MGA for analysis.

The ATB and the Infantry School (USAIS) jointly selected 114 CMF 11 (11B, C, and H) and soldier's common tasks for this test. MGA staff produced performance measures, Skill Sustainment Exercises (SSEs), that were used for testing and training the tasks. MGA also produced a General Administrator's Guide detailing the use of the SSEs and specific guides for each SSE. The training and data collection phases of this operational test were jointly conducted by a task force made up of four officers from ATB, four officers of USAIS, and two NCOs from SQT Management Directorate. Data reduction and analysis was performed by MGA staff members.

In-Course Phase

Soldier participants received standard POI introduction information and task demonstrations. They were then tested on the task using the SSE. A soldier received a GO on a task step if it was correctly performed. When the soldier made an error, he was given a NO GO on the step, the step was corrected, and the soldier told to proceed. No task instruction was given beyond correction of the error step. First trial data were recorded by the task force and transmitted by telecommunication to MGA for analysis.

Based on the first trial GO/NO GO data, for each task, STAR© provided the following estimates which were telecommunicated to the ATB task force:

- SSE training criterion: The number of successively correct (GO) trials the soldiers were required to perform in training so that 80% had stopped making errors. (USAIS selected this 80% level criterion.)

- STAR© estimate of the minimum End-of-Course performance.

- STAR© estimate of the retention interval in weeks for skill decay to 60% correct performance.

The soldiers were then trained to criterion on the SSEs and returned to the POI. SSE training and testing was scheduled so that it did not interfere with the administration of the standard POI.

Prior to the regularly scheduled end-of-course (EOC) refresher training, the task force members tested the soldiers to determine their EOC proficiency on each of the tasks.

ATB selected 44 tasks for in-unit testing. Twenty-two (22) tasks were tested at Fort Campbell after a 19-week interval. Four of these tasks were trained the day before the task force arrived for testing; as a result, these tasks were eliminated from the analysis. As expected, the soldiers made virtually no errors

on these tasks. Twenty-two (22) tasks were tested at Fort Lewis after a 21-week interval. Since many of the tasks had long retention intervals (e.g., one to three years), it was logistically impossible to wait until the STAR© interval had expired. Accordingly, minimum performance estimates were made using STAR© software adjusted to the field test intervals. Minimum performance estimates were also adjusted (upward) to account for any training that had been conducted in the units.

At Fort Campbell, the soldiers were tested by administering the SSEs one time. At Fort Lewis, the soldiers were tested and the data recorded for their first attempt at each task. Then the soldiers were trained until they performed each task step correctly. They were then given two additional trials to determine how many soldiers were performing the task correctly after attaining one correct trial. All testing and data collection were performed by the ATB task force.

## FINDINGS

### STAR© End-of-Course Estimates

The average STAR© end-of-course estimates were within two percentage points of the average observed end-of-course scores for tasks trained to criterion.

### STAR© Retention Estimates

The STAR© minimum performance estimates for the in-unit test were based upon two levels of calibration confidence. The confidence limits were 99% and 80% respectively. For the 99% confidence limit, it was expected that 99% of the observed task performance data would exceed the STAR© estimates. Thirty-eight (38) out of 40, or 95%, of the tasks met this expectation. For the 80% confidence limit, it was expected that 80% of the observed task performance data would exceed the STAR© estimates. Thirty-five (35) out of 40, or 87.5%, of the tasks met this expectation.

Sustainment Training Model

MGA's previous experience in process manufacturing operator training had shown that refresher training to a criterion of one GO was sufficient exposure for skill sustainment. This sustainment training method was tested at Fort Lewis.

The Fort Lewis soldiers were tested and then trained to criterion one perfect GO, they were then given two additional trials and their response accuracy recorded. Ninety-one (91) percent of the soldiers scored two consecutive perfect trials after meeting criterion one GO, indicating they had been effectively retrained.

The soldiers required 72% fewer sustainment training trials to reach criterion than the same soldiers had required learning the same tasks in the training base.

USE OF THE FINDINGS

STAR© software can be used to provide the following products which have application for unit and school training. These products are illustrated in the figure on page 6. The discussion below is keyed to the figure by Roman numerals.

Criterion (I)

Training to the STAR© accuracy criterion yields predetermined predictable performance, making it possible to trade off performance versus training cost.

End-of-Course Estimates (II) and Training Recommendations (III)

The ability to predict EOC performance on the basis of a small sample of first trial data makes it possible to audit, refine and develop training to meet predetermined performance objectives in the training base.

Sustainment Cycles (IV)

Using the STAR© calibration feature, it is possible to generate a variety of skill sustainment strategies and plan individual skill sustainment training in active and reserve units. For example, these planning strategies might emphasize task criticality, integration of individual skill sustainment in collective training exercises or cross training.

Refresher Training (V)

Training to criterion one GO provides sufficient exposure to retrain soldiers in units. This retraining represents a significant saving over initial training.

In-Unit Initial Individual Skill Training (V)

All of the procedures used in this effort can be transported to active and reserve units for initial individual skill training. This training will yield predictable results on tasks that are not trained in the training base as well as new weapon training tasks and career advancement training.

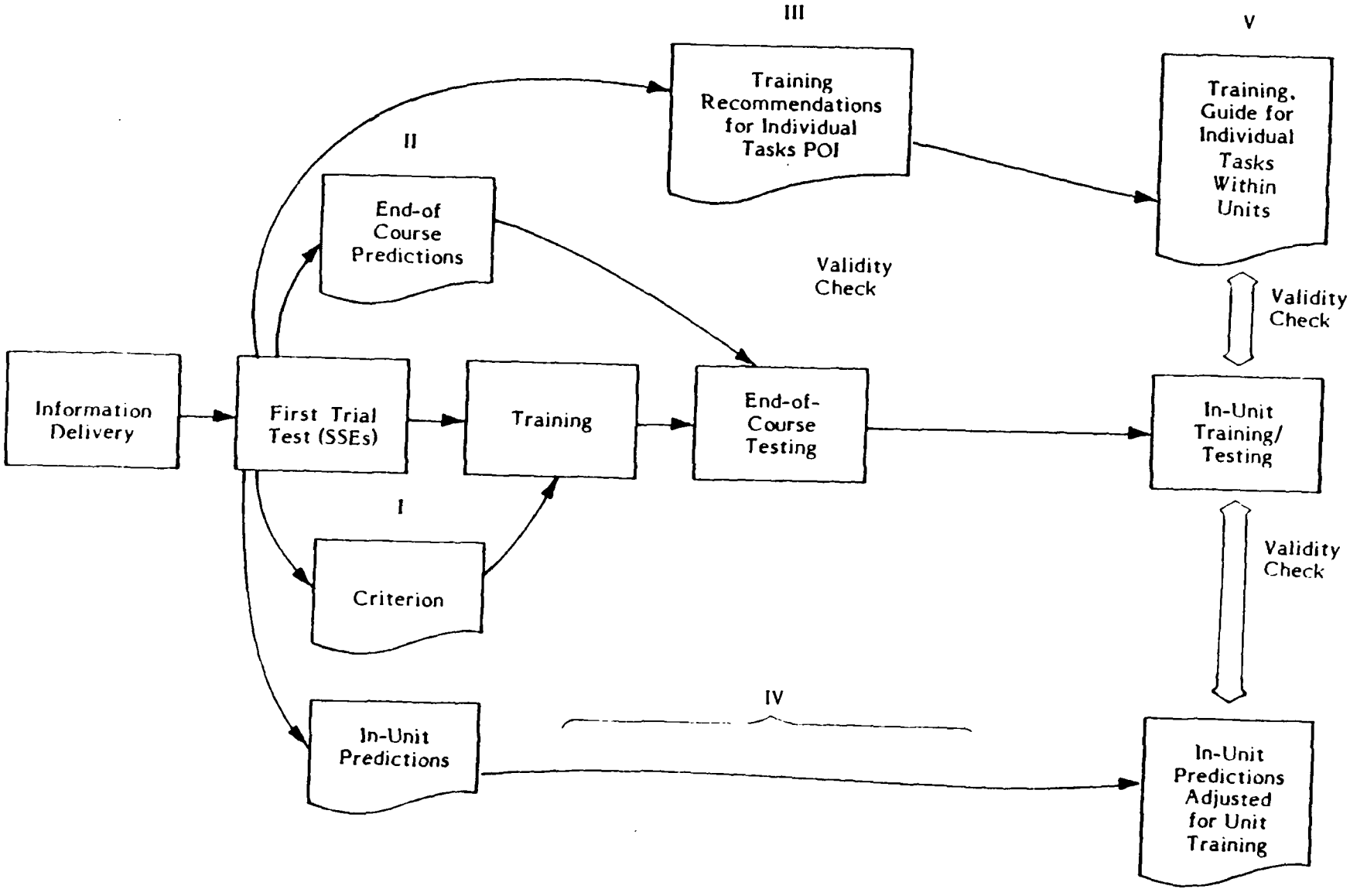



FIGURE 1: STAR DATA BASE PRODUCTS DEVELOPED IN THIS OPERATIONAL TEST

# I. INTRODUCTION

## BACKGROUND

The Army is required to maintain a stabilized, ready force. Integral components of this requirement are: modernization of the force; mobilization preparation of the force; and maintenance of known force capability for immediate response to threat. To ensure the success of this mission, the Army must train and sustain individual and collective soldier skills at specified levels. The Army Training Board (ATB) has initiated a large scale program with the goal of determining training frequencies and evaluation cycles for individual and collective skills in both active and reserve components. This report addresses one component of this program - the sustainment of individual skills at required levels of proficiency. Specifically, this report summarizes the results of an operational test to verify the ability of existing technology to estimate training and skill retention outcomes in Army schools and units.

The test came about for two reasons. First, the Army has a requirement to train and maintain specified performance levels for individual soldier tasks, but the Army has no validated tool to estimate minimum skill training and retention proficiency.

Second, McFann, Gray & Associates, Inc., (MGA) had developed and validated analytic computer software that permitted such estimation for individual tasks in non-military educational and process manufacturing training settings. However, the MGA Skill Training and Retention[C] (STAR) software had not been validated for Army tasks.

As a result of these two considerations, it was decided to conduct a pilot operational test of STAR in a military training base. This study was conducted as an engineering operational test and verification of the usefulness of STAR. It was not a basic research study.

## II. APPROACH

### PILOT OPERATIONAL TEST

MGA and ATB conducted a pilot test in which STAR was used to estimate end-of-course (EOC) scores for three Artillery OSUT tasks at Fort Sill. The tasks by MOS were:

- 13-B: Emplace and recover the collimator (collimator)
  Prepare semifixed ammunition (ammunition)
- 13-E: Prepare a surveyed firing chart (firing chart)

The STAR software program analyzed the soldiers' first trial performance data and provided an estimate of the performance score that would result at EOC. The estimated EOC scores represented the lowest performance which we expected on each of the tasks. Therefore, we expected the actual field data would equal or exceed our estimated score if the software was valid for Army tasks. The estimates of EOC scores were valid as shown in Table 1.

TABLE 1: PILOT OPERATIONAL TEST RESULTS

| TASK | TRAINING READINESS | |
|---|---|---|
| | MGA SOFTWARE ESTIMATE | ACTUAL FIELD DATA |
| Emplace and Recover the Collimator | 94% | 95% |
| Prepare Semi-Fixed Ammunition | 90% | 92% |
| Prepare a Surveyed Firing Chart | 80% | 91% |

The details of the Fort Sill study are contained in the report Optimization of Skill Retention Through Initial Training Analysis and Design, Rigg, K.E., and Gray, Burl B., 1982.

Based upon the demonstrated utility of the MGA software for estimating EOC performance for these artillery tasks from initial performance, the decision was made to undertake a large scale verification of the MGA software for both EOC and retention intervals. If the data held up and indications were that it had practical utility, then the Army would have made an important step forward in providing a tool to units in the field to plan individual training based upon skill retention and skill sustainment.

## SUPPLEMENTARY VALIDATION AND DATA BASE DEVELOPMENT

### Overview

The supplementary validation was conducted in two phases. The training base phase was conducted at the U.S. Army Infantry School (USAIS), Fort Benning, and retested the STAR capability to estimate minimum performance scores. The in-unit phase was conducted at Forts Campbell and Lewis and tested the capability of STAR to estimate minimum skill retention scores.

The ATB and the Infantry School initially selected CMF 11 and Soldier's Common Tasks that are critical to a broad scope of the Army's mission for this test. The testing phase of the study was jointly conducted by a task force of four officers from ATB (including the COTR), four officers of USAIS and two NCOs from SQT Management Directorate, and MGA staff researchers.

The following operational decisions were reached:

- First, ATB and MGA would conduct this effort as a joint activity.

- Second, the tasks selected for study would be tasks that are critical to a broad scope of the Army's mission. The USAIS and ATB selected 114 tasks. These tasks were drawn from the Common Tasks, MOS 11B, 11C, 11H and AS E 9 and C2.

- Third, MGA would train the ATB task force in the appropriate

technology for obtaining initial soldier performance, EOC performance, and in-unit performance.

- Fourth, the ATB task force would conduct both the criterion training and verification testing. Task introduction and task demonstration was conducted by USAIS committee instructors.

- Fifth, MGA would provide estimates of EOC performance and performance score estimates for various retention intervals. These estimates would be based upon soldiers' initial performance on the tasks and derived from the MGA computer software.

- Sixth, a user's guide or handbook would be prepared which included, for each CMF 11 task, tested information on the frequency and amount of refresher training required to maintain performance.

- Seventh, in addition to validating the MGA computer program, MGA and ATB would select those tasks and variables judged most related to skill retention and decay and generate a composite score using those tasks. Thus, tasks would be categorized according to the number of features they have that are thought to contribute to skill decay. The idea was to determine if it was possible with these categories to provide a readily useable prediction of those tasks most susceptible to skill decay and therefore requiring more frequent sustainment or refresher training.

The focus of this study has been to test existing technology in a field setting, with the emphasis on spelling out what actions are required to permit application of the technology in the field. The aim is utilization of existing technology through adoption or adaption to Army requirements, not generation of new technology. The remainder of this report details the method used, the results of the study, and the implications for applying the tested technology within the Army.

Figure 2 is a graphic overview of the operational test sequence.

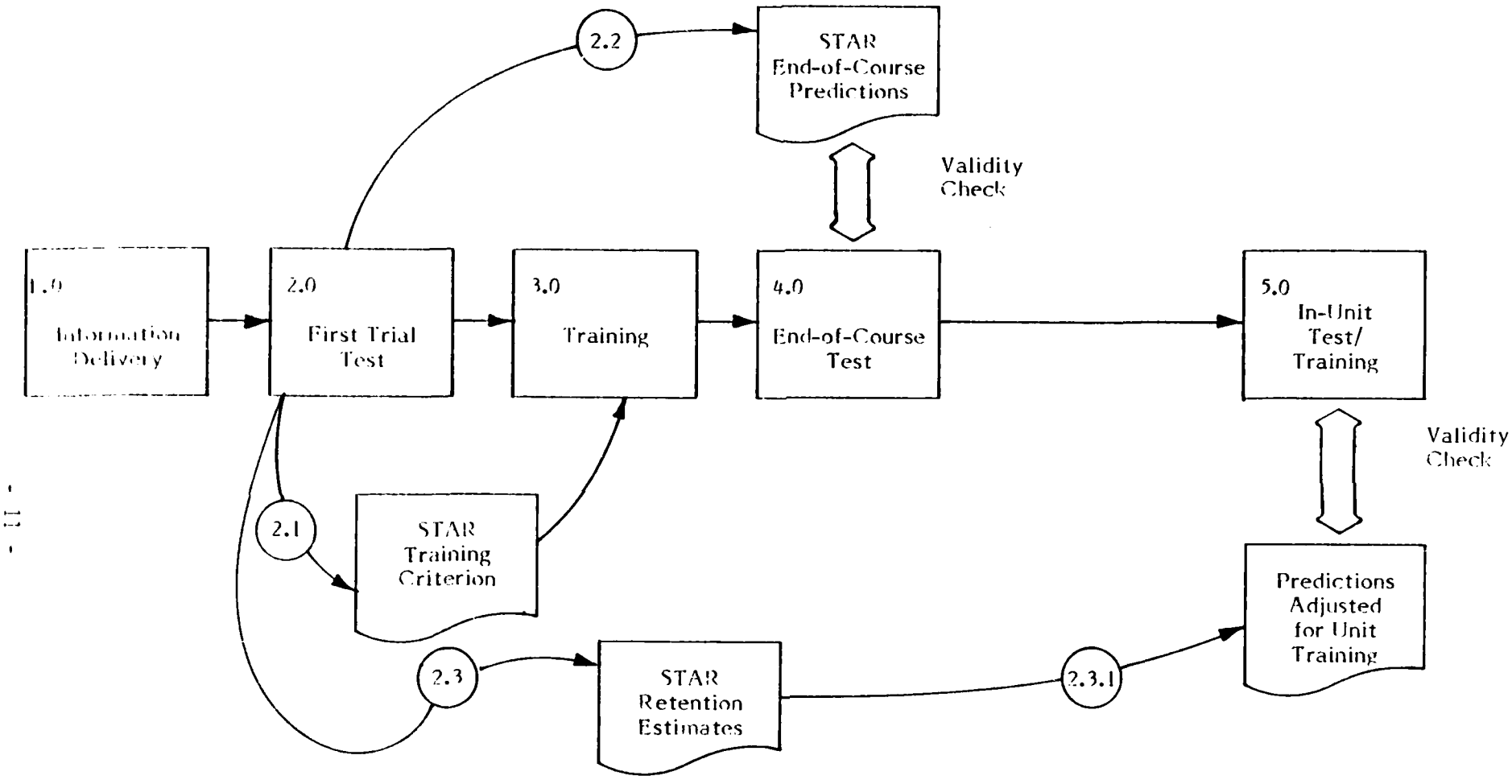



FIGURE 2: PROGRAM OPERATIONAL TEST SEQUENCE

The major milestones are numbered boxes 1.0 through 4.0. They are:

1.0 Information Delivery. All of the soldier participants received the standard POI introduction and demonstration prior to their first practice opportunity on each task.

2.0 First Trial Test. Soldier participants were then separated from the non-participants and given a test on the task. These data were analyzed using the STAR software and three estimates resulted:

2.1 Criterion. The number of successive correct training trials necessary to ensure that 80% of the soldiers had stopped making errors in training.

2.2 End-of-Course Prediction. Based on first trial data, STAR estimated the minimum end-of-course performance for each task.

2.3 In-Unit Prediction. Based on first trial data, STAR estimated the interval over which performance would decay to 60% in the absence of training or practice.

3.0 Training. Training was conducted according to four procedures that will be discussed in a following section.

4.0 End-of-Course Testing. Prior to the normally scheduled end-of-course POI reinforcement training, soldiers were given a test on each task for which they had received training. The EOC results were compared to the STAR predictions to test the validity of these estimates.

5.0 In-Unit Training and Testing. STAR sofware allows the user to calibrate retention predictions for any arbitrary retention interval. STAR will then generate estimates of minimum performance at

selected intervals. Soldiers were tested after 19 weeks at Fort Campbell and after 21 weeks at Fort Lewis. The STAR in-unit estimates were adjusted both for these intervals and for unit training that had taken place since graduation from the training base (see Figure 2, 2.3 and 2.3.1). In these instances, the estimates were revised upward, and the revisions were made prior to testing. The in-unit results were compared to the STAR predictions to test the validity of these estimates.

Skill Sustainment Exercises

STAR requires a stey-by-step performance measure for each task. To obtain these data for each task, MGA staff members developed data gathering instruments called Skill Sustainment Exercises (SSEs). SSEs provided a consistent means of measuring task performance before and after training. SSEs were used to collect the first trial, EOC, and in-unit performance data.

The SSEs were developed by the MGA staff who performed a front-end analsyis of each of the 144 tasks that were included in the study. Inputs for this analysis were: soldier's manuals, technical manuals, field manuals, existing task analyses, job aids, training aids, POIs and POIQTs for each task, and other relevant government publications. The front-end analysis consisted of an allocation of functions between the soldier and the equipment, a task analysis that detailed the steps required to perform the task, and a behavioral task analysis that clustered and sequenced task steps according to the relevance of available learning cues. For some short tasks, this task analysis provided the final SSE. For longer tasks, redundant task steps were eliminated to prepare the SSE. The criteria for all SSEs were:

- Each SSE step required a single action.
- The action or result of the action must be observable.
- The action must be scoreable as a "GO" or a "NO GO."

- The action must follow a logical sequential progression toward the achievement of the task goal.

- The SSE learning sequence must be consistent with current POI training sequence.

In addition to the SSEs, MGA developed a general administrator's guide to train the task force in the SSE data collection and training procedures. For each SSE, MGA developed an SSE Requirements Sheet that detailed the personnel, equipment, and procedures required to conduct the training and data collection. The SSE task and training development steps are illustrated in Figure 3. Examples of all SSE materials are contained in Volume III.

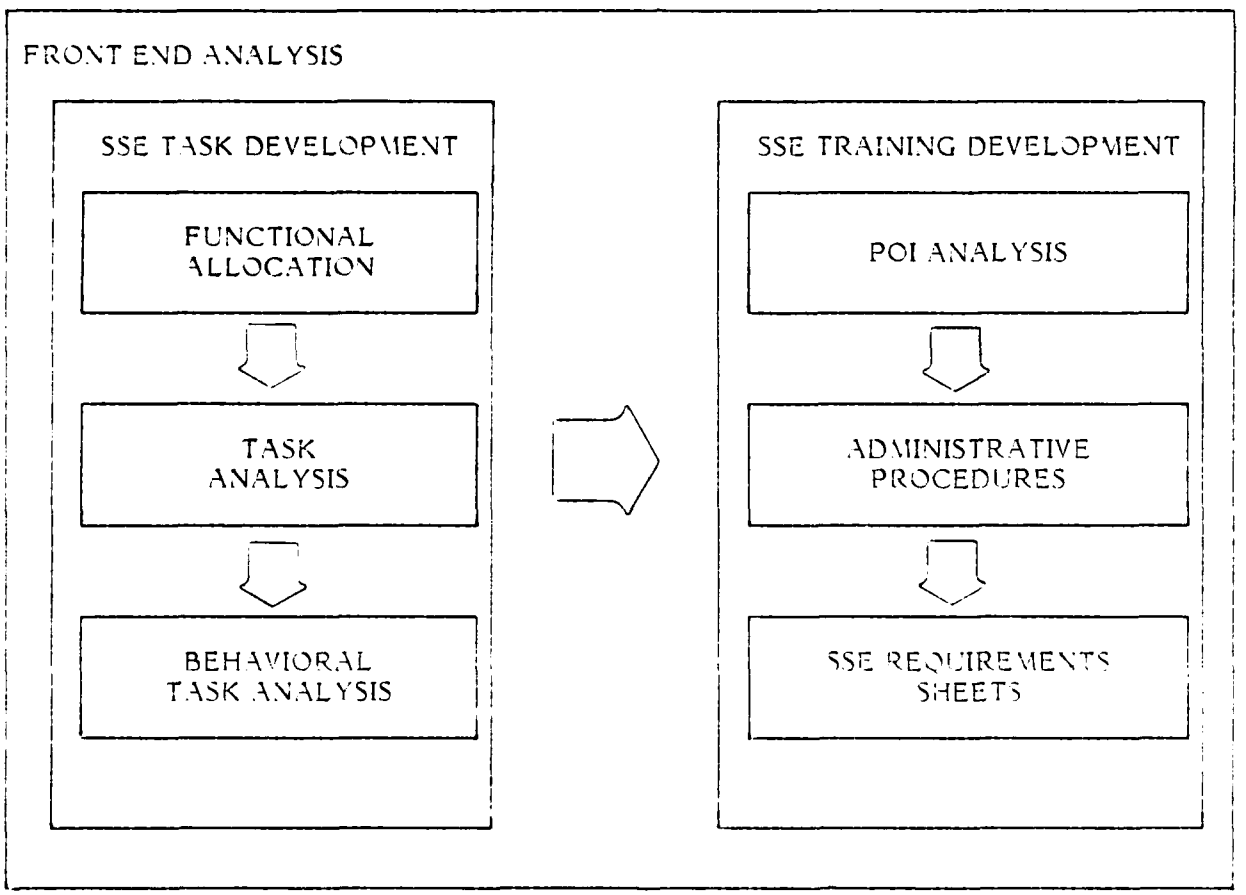



FIGURE 3: STEPS IN DEVELOPING SSE MATERIAL

## IN-COURSE PHASE

### Training of Data Collectors and Trainers

The data collectors and trainers were trained at Fort Benning during the two weeks prior to the start of data collection. Two MGA staff members traveled to Fort Benning to provide quality assurance and coordination during this start-up period. The data collectors and trainers were trained to administer and score the SSEs to ensure accurate data for input to STAR.

Prior to training, the Infantry School, in coordination with the ATB task force, was required to specify the SSE training criterion. This criterion is an interim standard and specifies the level of accuracy the soldiers have to achieve before returning to the POI for Soldier Manual Standard Training. The School selected an accuracy of 80% GO. This meant that the soldiers would be trained using the SSE until 80% of them had stopped making errors. (At least eight of ten soldiers would be able to perform the task 100% correctly on the next trial.)

The soldiers received current POI orientation and a demonstration of each task from the Infantry Training Group Cadre or the ATB task force. At the first opportunity to practice each task, the soldiers were removed from POI training and required to perform the task. Each soldier was scored on the SSE for the first trial. When a soldier received a NO GO on an SSE step, he was immediately stopped, informed of the correct step, and required to perform the step correctly before continuing. These data were electronically communicated to MGA for STAR software analysis.

MGA analyzed the first trial data and provided the following information:

- The number of successively correct trials the soldiers would have to perform for the software to indicate that the 80% criterion was met.
- An estimate of the lowest expected performance score at the end of course.

- The time interval (in weeks after the course) in which soldier proficiency would decay to 60%.

The study design and the STAR software requirements called for soldiers to be trained to SSE criterion following the initial trial and then returned to the POI for training to soldier manual standard. However, since this study was superimposed on the POI training, the training fell into four categories. The soldiers were:

- Trained to STAR SSE criterion and to soldier manual standard (Training Method 1)
- Trained to STAR SSE criterion only (Training Method 2)
- Trained to soldier manual standard only (Training Method 3)
- Initial trial data collected and retested without intervening training (Training Method 4).

Only Training Method 1 met all the STAR training requirements for optimal estimation accuracy. The other three methods each lacked some of the requirements, thereby reducing expected estimation accuracy.

SSEs were used for pre- and post-testing under all four training methods. Training was performed by the task force to minimize turbulence in current POI training. The training and testing cycle is illustrated in Figure 4.

Subjects

Two platoons of trainees were selected from two training companies. One company was beginning training and the other was in the seventh week of the POI. This overlap allowed the task force to collect all data in approximately eight weeks. Table 2 shows the number of trainees who participated in all phases of the study (In-Course and In-Unit) by MOS and advanced skill tasks.

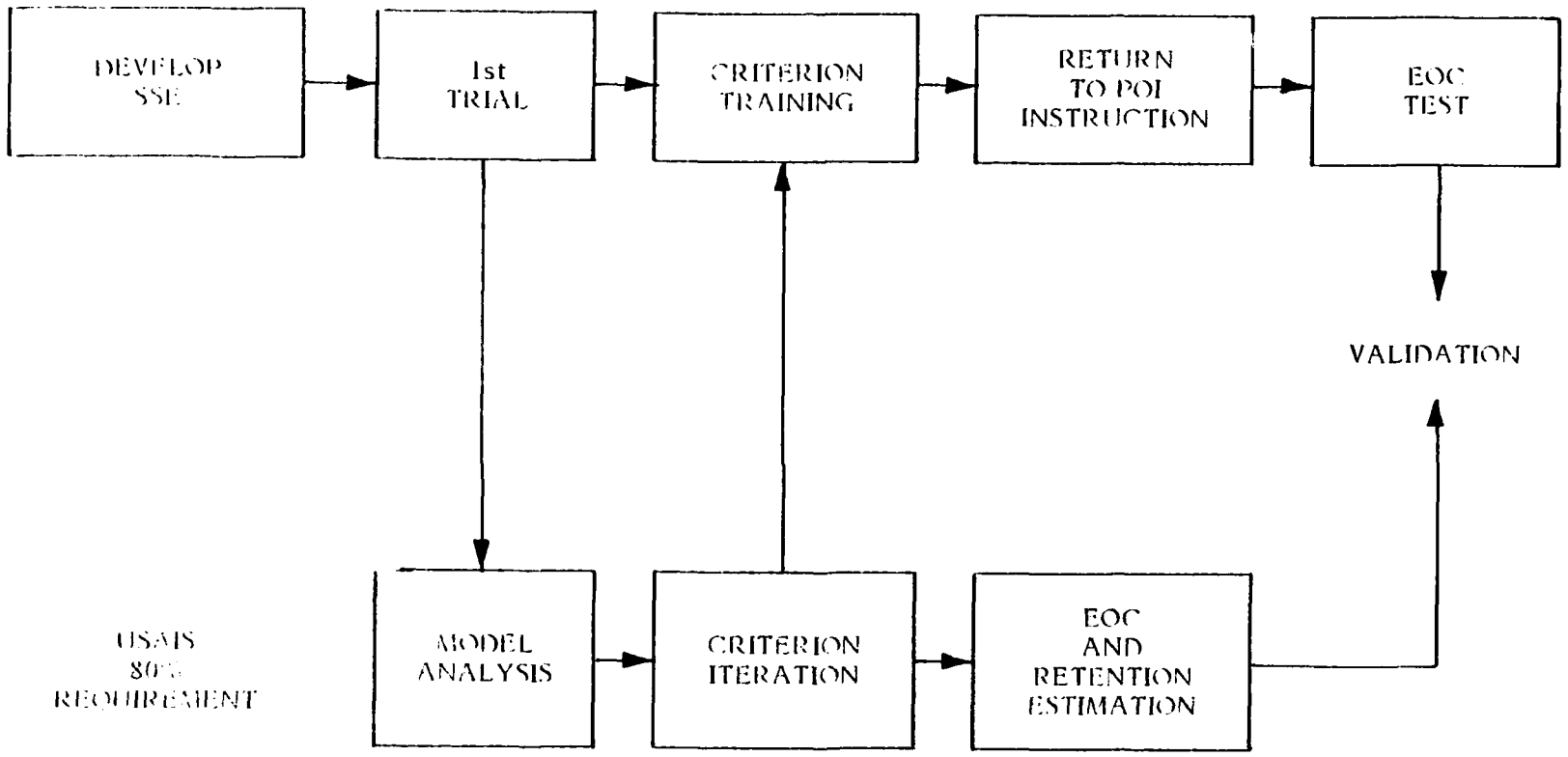



FIGURE 4: TRAINING TESTING CYCLE

TABLE 2: SOLDIER PARTICIPANTS

| Number of Soldiers | Training Tasks |
|---|---|
| 16 | 11B AND COMMON TASKS |
| 20 | M60, NIGHT SIGHTS AND STT TASKS |
| 13 | 11C TASKS |
| 8 | 11H (TOW) TASKS |
| 10 | 11B (DRAGON) TASKS (ASI E9) |
| 67 | TOTAL |

Table 3 shows the distribution of age, formal educational achievement, and GT scores for the 67 soldiers who participated in the study.

TABLE 3: DISTRIBUTION OF AGE, FORMAL EDUCATIONAL ACHIEVEMENT AND GT SCORES FOR SOLDIERS PARTICIPATING IN STUDY

| | Age/ Years | Education/ Years | GT Score |
|---|---|---|---|
| Mean | 20.46 | 11.75 | 107.15 |
| S.D. | 2.93 | 0.93 | 12.51 |
| Range | 17 to 28 | 9 to 14 | 74 to 143 |

## STAR Software Data Requirements

The MGA software requires a minimum of 200 GO/NO GO data points per task to yield stable estimates. In general, the distribution of subjects fulfilled this requirement. Tasks that did not meet this requirement are noted in the data appendix, Volume II.

The STAR software flags tasks in which the estimated EOC variability and observed EOC variability differ, i.e., when the observed error is greater than expected. When a task is flagged in this way it is necessary to re-analyze the total training and data collection to enable STAR to be used to estimate requirements for that task.

## End-of-Course Data

The ATB task force used the SSEs to collect end-of-course data prior to POI reinforcement training. These data were electronically transmitted to MGA for analysis. Paper copies of all of the raw data collected during the study were sent to MGA to ensure the accuracy of the electronically transmitted data.

## IN-UNIT PHASE

### Overview

The soldiers who were tested at Fort Benning were in New Manning System units which went to Fort Campbell, Kentucky and Fort Lewis, Washington. They were re-tested on 44 selected tasks to validate STAR estimates of task performance after specific retention intervals. Twenty-two tasks were tested at Fort Campbell 19 weeks after the completion of Fort Benning training. Twenty-two additional tasks were tested at Fort Lewis 21 weeks after the completion of Fort Benning training. These intervals were chosen as the best trade-off between theoretical retention decay times and unit schedules to minimize unit turbulence.

The STAR retention estimates were based on the time interval between training and retention testing. Therefore, they were revised to take into account any refresher training that occurred between the end of the course and the retention test date.

### Fort Campbell Data Collection Procedures

The ATB task force collected data using the SSEs that were administered during the training phase. Each soldier was given the SSE one time and GO/NO GO data were recorded for each performance measure of the SSE. The 22 tasks were distributed across M60, TOW, DRAGON, and MORTAR weapon systems. In-unit refresher training had been conducted for many of the tasks that were tested. The dates and extent of this training were collected from the company training NCO and company commander. As it turned out, all but the TOW tasks had received refresher training during the 19 week interval. The Fort Campbell tasks are listed in Table 4. The complete data displays are presented in Volume II, Appendix 3.

## Fort Lewis Data Collection Procedures

With one exception, the Fort Lewis data collection procedures were identical to those employed at Fort Campbell. All 22 tasks were tested for retention proficiency, tasks were then trained to criterion 3 correct trials. The results of this criterion training will be discussed in a later section of this report. All 22 tasks tested at Fort Lewis were selected from the Soldier's Common Tasks. The Fort Lewis tasks are listed in Table 5. The complete data displays are presented in Volume II, Appendix 3.

TABLE 4: FORT CAMBPELL TASKS

| | |
|---|---|
| 071-321-1601 | Prepare an M16 Plotting Board for Operation (Pivot Point) |
| 071-321-1602 | Process FO Corrections Using an M16 Plotting Board (Pivot Point) |
| 071-321-3901 | Place a Ground Mounted 81mm Mortar Into Action |
| 071-321-3904 | Lay Mortar for Deflection and Elevation (D&E) (Ground/Carrier Mounted) |
| 071-321-3909 | Refer Sight and Realign Aiming Posts |
| 071-321-3910 | Reciprocally Lay Mortar Using M2 Aiming Circle and Place Out Aiming Posts |
| 071-316-2521 | Prepare an Antiarmor Range Card |
| 071-317-0000 | Prepare an Antiarmor Range Card (DRAGON) |
| 071-317-3301 | Conduct a Pre-operational Inspection of the DRAGON Tracker and Round |
| 071-317-3302 | Prepare the DRAGON for Firing |
| 071-317-3303 | Determine if a Target is Engageable (DRAGON) |
| 071-317-3304 | Demonstrate Correct DRAGON Firing Positions |
| 071-317-3306 | Perform Immediate Action Procedure for a DRAGON Misfire |
| 071-317-3308 | Perform Emergency Destruction Procedures on a DRAGON |
| 071-312-3001 | Load, Reduce a Stoppage, and Clear the M60 Machinegun |
| 071-316-2500 | Assemble the TOW Launcher |
| 071-316-2501 | Perform Operator Maintenance on a TOW Launcher |
| 071-316-2502 | Conduct System Self Test and Pre-operational Inspection of TOW Launcher |
| 071-316-2503 | Load, Arm, and Unload an Encased TOW Missile |
| 071-316-2504 | Perform Immediate Action for a TOW Misfire |
| 071-316-2505 | Determine if a Target can be Engaged by TOW |
| 071-316-2516 | Determine TOW Firing Limitations |

TABLE 5: FORT LEWIS TASKS

| | |
|---|---|
| 071-316-0814 | Identify Friendly and Threat Armored Vehicles |
| 071-318-2201 | Prepare an M72A2 LAW for Firing; Restore M72A2 LAW to Carrying Configuration |
| 071-318-2203 | Apply Immediate Action to Correct a Malfunction on an M72A2 LAW |
| 071-329-1001 | Identify Terrain Features |
| 071-329-1002 | Determine the Grid Coordinates of a Position Using the Military Grid Reference System |
| 071-329-1003 | Determine a Magnetic Azimuth Using a Compass |
| 051-192-1002 | Install an M16A1 Mine Bounding Antipersonnel Mine without Tripwires |
| 051-192-1008 | Install M21 Metallic Antitank (AT) Mine |
| 051-192-1022 | Locate Mines by Probing |
| 051-192-1502 | Install and Fire/Recover an M18A1 Claymore Mine |
| 081-831-1013 | Give First Aid to a Blood-Agent Casualty |
| 081-831-1011 | Give First Aid to a Nerve-Agent Casualty |
| 051-192-1007A | Decontaminate Your Skin |
| 031-503-1006 | Give the Alarm for a Chemical or Biological (CB) Hazard |
| 031-503-1002 | Put on and Wear an M17-Series Protective Mask |
| 071-311-2003 | Load, Reduce a Stoppage, and Clear an M16A1 Rifle |
| 071-311-2001 | Perform Operator Maintenance on an M16A1 Rifle, Magazine, and Ammunition |
| 081-831-1001 | Perform Mouth-to-Mouth Resuscitation |
| 081-831-1005 | Prevent Shock |
| 081-831-1006 | Splint a Suspected Broken Arm or Leg |
| 081-831-1016 | Put on a Field or Pressure Dressing |
| 071-331-0803 | Collect/Report Information (SALUTE) |

## III. STAR RESULTS

The results will be described separately for the In-Course and In-Unit study phases. In both phases the results center around the ability of STAR to make useful EOC and retention performance estimates.

IN-COURSE

EOC performance scores were estimated based on initial task performance. The tasks were then trained under one of the four training methods described in Section II. The major results of the In-Course Phase are presented in Table 6. The findings are:

- Average STAR EOC estimates were within two (2) percentage points of the average EOC observed scores for the criterion-trained tasks (Training Method 1 - average estimate = 95%, average observed = 93%; Training Method 2 - average estimate = 92%, averaged observed = 91%).

- Average EOC scores were greater for tasks which were trained to criterion, 93% and 91% (Training Methods 1 and 2), than for those not trained to criterion, 85% and 80% (Training Methods 3 and 4).

- A greater percentage of tasks that were trained to criterion exceed 80% and 90% EOC scores than tasks not trained to criterion.

The task-by-task data are contained in Volume II, Appendix 3.

TABLE 6: SUMMARY OF EOC RESULTS

| Training Method | Number Tasks | Average STAR Estimate | Average Observed Score | Number of Observed Task Scores $\geq$80% | Number of Observed Task Scores $\geq$90% |
|---|---|---|---|---|---|
| 1 | 7 | 95% | 93% | 7 (100%) | 7 (100%) |
| 2 | 29 | 92% | 91% | 27 (93%) | 19 65%) |
| 3 | 12 | 93% | 85% | 7 (58%) | 5 (42%) |
| 4 | 65 | 93% | 86% | 49 (75%) | 29 (45%) |

Revision of the STAR Procedure

The Statement of Work included provisions for practical revision of STAR based upon field data and experience. No revisions of the STAR sofware were necessary; however, the ATB task force found that, given available staff and resources, it was impractical to train to the STAR criterion in many instances. MGA and the COTR agreed on a field expedient revised criterion based on the first trial data. The rules for this criterion are shown in Table 7.

TABLE 7: FIELD EXPEDIENT CRITERION RULES

| First Trial Error | Field Criterion |
|---|---|
| $\leq$5% | 3 |
| $\leq$10% $>$5% | 6 |
| $>$10% | STAR Value |

For example, a task whose average correct performance was 91% would be trained to six successively correct trials.

These rules were developed about half-way through the data collection and, therefore, were not universally applied. Data were collected on 32 tasks in which the field expedient criterion was used. The average criterion used was 3.5 successively correct trials. The STAR estimate for this criterion is that 43% of the soldiers would stop making errors with this criterion. The STAR criterion for 80% error free performance was 8.1 successively correct trials for the same tasks. The impact of the lower criterion was not evaluated in this effort. However, STAR simulations show that the lower criterion is a source of variability. This issue should be addressed in future applications of STAR technology.

IN-UNIT

Two types of STAR retention estimates were made. The first estimate is the interval of time over which performance will decay to 60%. The 60% strategy was selected by ATB for this study. The second estimate is an estimate of retention performance for various, specified intervals of time following training or refresher training. The first estimate (i.e., 60% estimate) was based on initial performance. The 60% retention intervals ranged from a few weeks to more than three years. It would have been logistically difficult to verify STAR estimates following each of these intervals. Therefore, the second estimates were made based on the availability of the test soldiers at Fort Campbell and Fort Lewis, 19 and 21 weeks after EOC, respectively. Minimum performance estimates were generated using STAR for each task based on the 19 and 21 week retention intervals between training and testing. At Forts Campbell and Lewis, company officers and NCOs were interviewed to determine which of the tasks had received unit refresher training. This information was analyzed by STAR to further revise the STAR performance scores. In all cases, the estimates were revised upward prior to retention testing at Fort Campbell and Fort Lewis. These task-by-task estimates are contained in Volume II, Appendix 3.

STAR retention estimates generated for this study are estimates of the minimum performance that will occur after a specified retention interval. The STAR software produced two estimates for retention performance in each task:

80% and 99% calibration levels. The 80% calibration provides the higher minimum performance estimates of the two, but runs a greater risk (20%) that the actual retention score may fall below the estimate. The 99% calibration provides a lower minimum performance estimate, and consequently, lower risk (1%) that retention performance will fall below the estimate. The retention performance estimates were made for the specific interval which had passed for each task since it had been trained or retrained.

The results of the In-Unit Phase are summarized in Table 8 and Figure 5. The major findings were:

- For the 80% STAR calibration, retention performance on 35 of 40, or 87.5%, of the tasks met or exceeded the STAR minimum performance estimates. The frequency distribution of the actual scores minus the estimated scores is shown in Figure 5.

- For the 99% STAR calibration, retention performance on 38 of 40, or 95% of the tasks met or exceeded STAR minimum performance estimates. The frequency distribution of the actual scores minus the estimated scores is shown in Figure 5.

- The average absolute difference between estimated and actual scores was 9 percentage points at the 80% calibration and 21 percentage points at the 99% calibration.

The complete task-by-task data are contained in Volume II, Appendix 3.

TABLE 8: SUMMARY OF IN-UNIT RESULTS

| Training Method | Number of Tasks | Numbers of Tasks Exceeding Estimate | |
|---|---|---|---|
| | | .99 Calibration | .80 Calibration |
| 1 | 4 | 4 | 3 |
| 2 | 25 | 23 | 21 |
| 3 | 11 | 11 | 11 |
| Total | 40 | 38 | 35 |

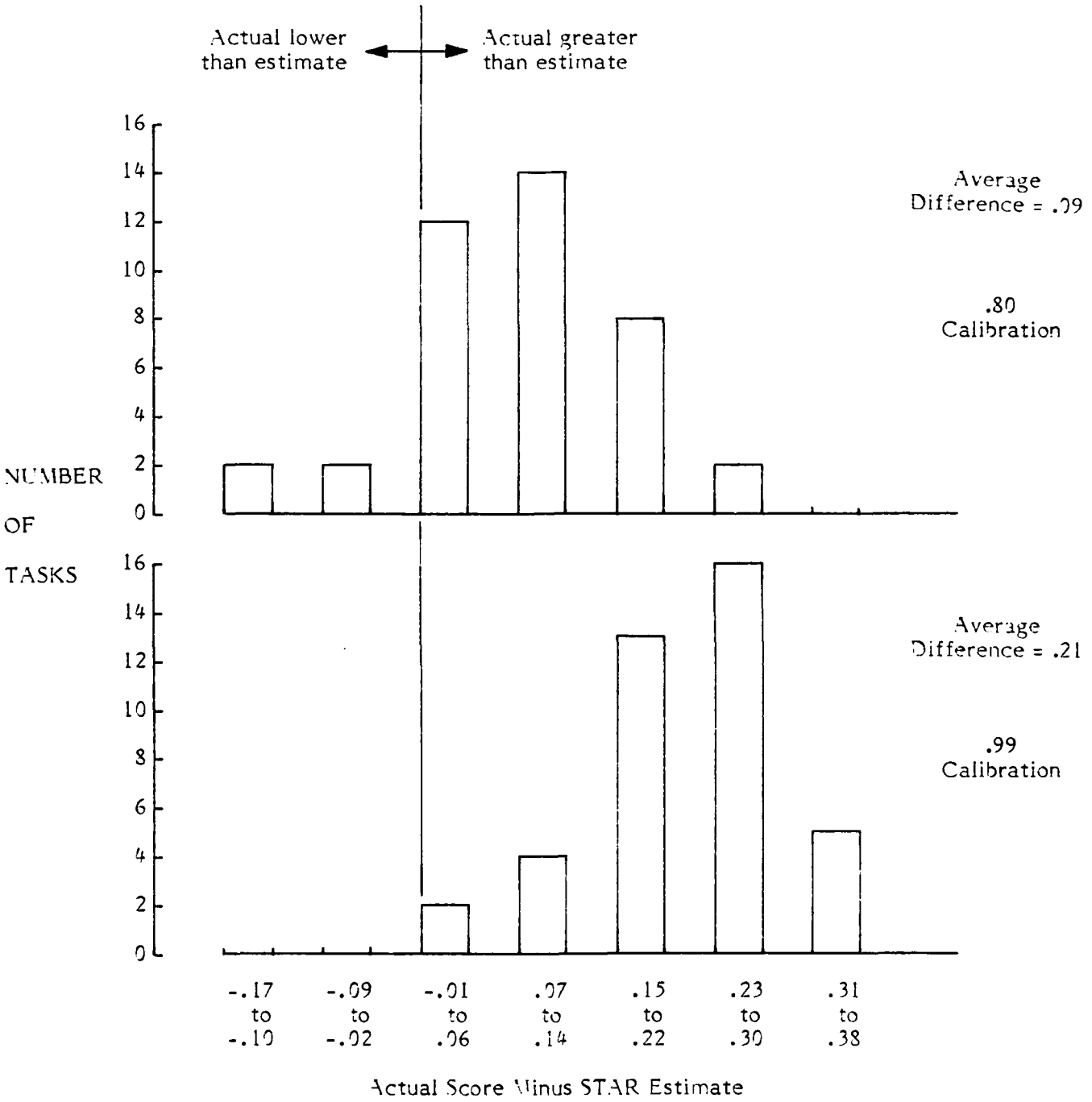



FIGURE 5: NUMBER OF TASKS VERSUS ACTUAL SCORE MINUS STAR ESTIMATE

## In-Unit Sustainment Training at Fort Lewis

As noted earlier, soldiers at Fort Lewis were not only tested, they were also trained to criterion. This part of the study was an offshoot of previous work by MGA staff. MGA has learned in manufacturing settings that sustainment training to criterion one GO was sufficient to raise the performance of technicians to approximately 100%. The ATB suggested testing this observation at Fort Lewis. The soldiers were trained to criterion one GO, and then given two additional trials. Table 9 summarizes the percentage of soldiers reaching criterion one GO on the first through the seventh trial.

TABLE 9: TRIAL NUMBER ON WHICH SOLDIERS MET CRITERION ONE GO

| Trial Number | Percent GO |
|---|---|
| 1 | 32.8 |
| 2 | 46.2 |
| 3 | 16.8 |
| 4 | 1.6 |
| 5 | 2.0 |
| 6 | 0 |
| 7 | 0.4 |

Ninety-one percent of the soldiers scored two consecutive perfect trials after meeting criterion one GO. Based on this, we feel that the soldiers had been effectively retrained. The soldiers required 466 sustainment training trials to reach criterion one GO. These same soldiers, learning these same tasks at Fort Benning, required 1,659 trials to reach criterion. Sustainment training represents a 72% training reduction over initial training. MGA's experience with other training indicates that continued sustainment training reductions will be demonstrated over time. Practical application and operational testing would validate this for Army unit training.

## IV. TASK CATEGORIZATION

### BACKGROUND

ATB requested that as an adjunct to the STAR validation, this study include a test of the ability to categorize tasks according to their skill retention characteristics. The STAR validation study included the logistical requirements for such a small task categorization study, so it was included as a side issue.

The task categorization effort attempted to determine if tasks could be categorized according to characteristics which relate to retention of task performance. If successful, a simple rule of thumb could be developed for estimating refresher training cycles based on task characteristics alone.

### APPROACH

MGA and ATB staff members selected a small set of task characteristics which are most often related, according to the research literature, to skill retention and decay. Seven variables were selected to describe each task. These variables were scored as either present or absent in each task. Each variable received a score of 1 or 0; 1 if the variable enhanced retention; 0 if it degraded retention. Each of the seven variables was given equal weight. The seven variables were summed for each task providing a task categorization score which ranged from 0 to 7. The higher the score the more resistant the task should be to skill decay and the easier and longer retained.

These task categorization scores were compared to later retention performance to determine if the expected relationship holds up. Because many other uncontrolled variables affect retention performance, a strong relationship is necessary to make task categorization a useful tool. Previous attempts to discover task features related to retention and skill decay have not yet yielded information in a form which can be validated or readily used in the field.

The results of these studies appear to lack application in the Army because:

- The relationships have not been strong enough to warrant application.

- The retention results are not estimated prior to training and are sensitive to training method and practice frequency.

- There is no method for estimating proficiency over practice intervals that are different from the interval at which the original retention data were collected.

The task categorization effort of this project was an attempt to address these issues.

The following seven task variables were used for the categorization effort:

- Task position in the POI

  It is expected that those tasks that are trained the earliest will be retained longer. Also, these tasks are more likely to be reinforced during the training cycle.

- Safety steps in the task.

  Safety measures usually conflict with the task mechanics. Retention of tasks containing safety measures will be degraded.

  Example: A DRAGON gunner is required to check the backblast area prior to sighting and firing the weapon. This safety step is quickly forgotten.

- Cognitive versus physical task.

  Physical tasks are more likely to require the integration of sensory

modalities than cognitive tasks. Predominantly physical tasks are retained longer than cognitive tasks.

Example: Firing the M60 machinegun integrates vision, kinesthesia, hearing, and tactile sensation. Cognitive tasks require the integration of mental skill, knowledge and procedure to produce the desired outcome. Example cognitive tasks would include SALUTE, Prepare an Antiarmor Range Card, TOW, and Shoot an Azimuth.

- Number of subtasks.

  Breaking a successive string of task elements into discrete subtasks decreases retention.

  Example: A sixteen step task taught as a whole unit will be retained better than a sixteen step task that is divided into two or more subtasks.

- Number of steps.

  Short tasks are retained better than long tasks. A long task is defined as 17 or more steps.

- Troubleshooting or branching task procedures.

  When task structure varies with external conditions of the "if....., then do ....." format, retention is degraded.

  Example: In the task Treat a Blood/Nerve Agent, the soldier branches on the basis of the victim's symptoms. This task is quickly forgotten.

- Procedural task.

  A procedural task contains a series of short, discrete, sequential motor responses: a response provides no cues for subsequent responses. Tasks having four or more procedural responses will not be retained as well as non-procedural tasks.

  Example: Performing Operational Checks and Maintenance (PMCS) on the M60 machinegun requires memorization of a series of procedures that are not immediately related to firing the weapon, and are forgotten more quickly than driving.

## RESULTS

Pearson Product Moment correlation coefficients were calculated between task categorization scores and EOC scores. Correlation coefficients were calculated for all tasks and for tasks within each of the four training methods. None of these correlations was statistically significant nor numerically large enough for practical utility. The finding that task categorization does not relate to EOC performance is not surprising since the training is designed to reduce the variability in performance by the end of course to somewhere between 80% and 100%. This restriction in the range of performance at EOC reduces the likelihood of obtaining a demonstratable relationship between task categorization and EOC performance.

A more likely place to find a relationship to the task categorization variables is in the longer term retention performance. An index of task retention was calculated which indicates the amount of change in task performance between EOC and retention several weeks later. This index is the ratio of the in-unit task retention score to EOC score. If this ratio is one (1), then retention performance was equal to EOC performance and there was no skill decay. As the ratio decreases, retention performance decreases and the task categorization score should decrease, if it, in fact, relates to retention performance. None of the correlations between task categorization scores and the retention index (i.e., by

training method and overall) were significant. Correlations between task categorization scores and absolute in-unit retention scores were also non-significant.

This lack of significant task categorization-retention correlations may be due to one or more of the following reasons:

- The task variables used were not appropriate.
- Other factors besides the task variables were stronger and overcame the effect of the task variables.
- Tasks cannot be categorized in a simple way to indicate expected retention performance.

Further research with more complex research designs in task categorization may produce methods and variables which have the potential of providing field-useable results. This limited study did not discover them through the attempt described above.

## DISCUSSION

This discussion will focus on what was learned or developed during this study that has application to the Army. This study was not basic research but was an operational verification of the STAR software. Overall verification of the STAR software occurred. The software program did provide useable EOC estimates, and in-unit retention estimates.

### ESTIMATION - CALIBRATION

The estimation standard employed for in-unit performance was minimum performance, i.e., the lower boundary of performance. We estimated what the minimum expected performance would be. This is a cautious estimate which maximizes the assurance that the actual performance will be equal to or greater than our estimate. The operational implication is that there is massive assurance that the skill will be sustained by using the estimated interval for sustainment training. The risk is that there will be tasks in which training is given before it is needed. As such, there will be unnecessary training at an additional cost.

There are several operational implications based on the strategy selected. To obtain maximum assurance that a performance will occur, there will be instances of unnecessary training and unnecessarily frequent sustainment training. To minimize the risk and associated cost of unnecessary training will result in less assurance that the desired performance will occur.

Policy decisions impact directly on calibration procedures which provide EOC performance and dictate sustainment frequency schedules. The percent of skill decay to be tolerated before refresher or sustainment training dictates frequency of training.

For either EOC or sustainment training, a mixed calibration approach can be employed. Accuracy or certainty of occurrence calibration might be higher for critical or dangerous tasks and lower certainty employed for non-critical tasks.

It is entirely possible to reduce the range of the EOC and retention estimates and thereby decrease the training risk. The most obvious, probably the least expensive, method is to increase initial performance through evolutionary change in the training materials and methods used in the training bases. Volume II contains an analysis of the 44 tasks that were tested in units and recommendations for training review. These recommendations, if implemented, would result in improved EOC performance and reduce the range of the retention estimates. Other broader changes in training show potential promise. These include adoption of a distributed (spaced) training model and the acceptance of a higher training criterion. Fort Benning has recently adopted a 90% criterion for POI qualification testing. STAR simulation indicates that this criterion will result in a minimum increase of ten percent in EOC retention scores. The impact of this new criterion can be readily evaluated with further field testing.

The important points are: (a) the STAR software is interactive and flexible; (b) policy decisions dictate how the software should be calibrated to provide cost-benefit trade-offs, and (c) once calibrated, the procedure is complete and need not be repeated.

## PERFORMANCE DATA

The STAR software requires a sample of first trial data input as a step-by-step performance measure for each task. Performance data were also required to measure EOC performance and in-unit retention.

The decision was made to develop special measuring instruments for this study. These instruments came to be called Skill Sustainment Exercises (SSEs). These SSEs provided a consistent means of measuring task performance before and after training. Care was taken to ensure that these performance measures were based on a front-end analysis of the tasks, and that the measures were consistent

with the POI. The SSEs are high fidelity reflections of the requisite task performance. They are consistent with but not always identical to Soldier Manual Standards. Both call for the same performance steps and require an observable scorable action. The Soldier Manual Standards also include time and condition standards, whereas the SSE calls only for demonstrated ability to perform the task.

The primary value of SSEs for this study was their utility as performance measures. The procedures used in developing the SSEs ensured that they were consistent the the POI and the Soldier Manual. Clearly, if available, other performance measures could have been employed.

## DATA BASE

As a result of this study, there exists a major data base for the CMF 11. One-hundred-fourteen tasks were extensively analyzed and developed into SSEs. EOC estimated and actual performance for each task is available. Estimates for retention or sustainment intervals, and verified data for a subset of these tasks exists.

A prototype trainer's guide was developed from the data base and is attached as an annex to this report. This guide was developed to demonstrate a single application of the data base. Clearly, further work is needed to implement data base uses and to integrate the data base products into the Army.

The value of such a data base is considerable. EOC performance by task with the existing instructional system is known. If training is revised, then the SSEs or comparable measures permit the training developer to predict the impact of the change. Also, the sustainment intervals by task are known. Thus, a management of a career management field is available. Audits can be performed, and resource allocation decisions checked out with data of this sort. These data should be provided to the Infantry School with the purpose of becoming part of a permanent data base.

## PROJECT PRODUCTS

The goal of this mutual effort between the Army Training Board and MGA has been to operationally test the STAR technology to determine if it can be developed into a practical, useable, and effective tool that can assist combat unit commanders in attaining and sustaining high levels of soldier performance. The principal focus of this work has been to discover how long it takes individual soldiers to perform central tasks to an established criterion, to what extent that performance is degraded over time, and what is required to retrain the individual to the desired level of proficiency.

The specific objective of this study has been the verification of the capability of the MGA STAR software to provide useful and practical data and procedures for the eventual development of such a tool. Overall verification of the STAR software occurred. The results demonstrate that the STAR software can be used to estimate end-of-training proficiency, the length of time such proficiency can be maintained without retraining, and the training necessary to regain proficiency after an interval of time. In addition, the software has a capability that enables trainers and training developers to determine trade-offs between performance outcomes and cost of training.

Figure 6 is a graphic recap of the STAR operational test showing the products of this work. For a given training delivery system, Fort Benning POI in this case, it is possible to establish a training CRITERION (I in Figure 6), that will determine the training effort required to meet a desired level of proficiency at the END-OF-COURSE (II in Figure 6). The POI can be adjusted to achieve a desired level of performance - TRAINING RECOMMENDATIONS (III in Figure 6). STAR retention estimates determine the frequency of necessary sustainment training on a combat unit-specific basis, adjusting for individual unit training schedules and priorities (IV in Figure 6). A TRAINING GUIDE (V in Figure 6) can establish training frequencies for tasks clustered either by weapon system retention interval or collective training exercises. This training guide, including the training methods and criteria, could be used both for sustainment training and for initial unit training of individual tasks that are not trained to Soldier's Manual Standard in the training base.

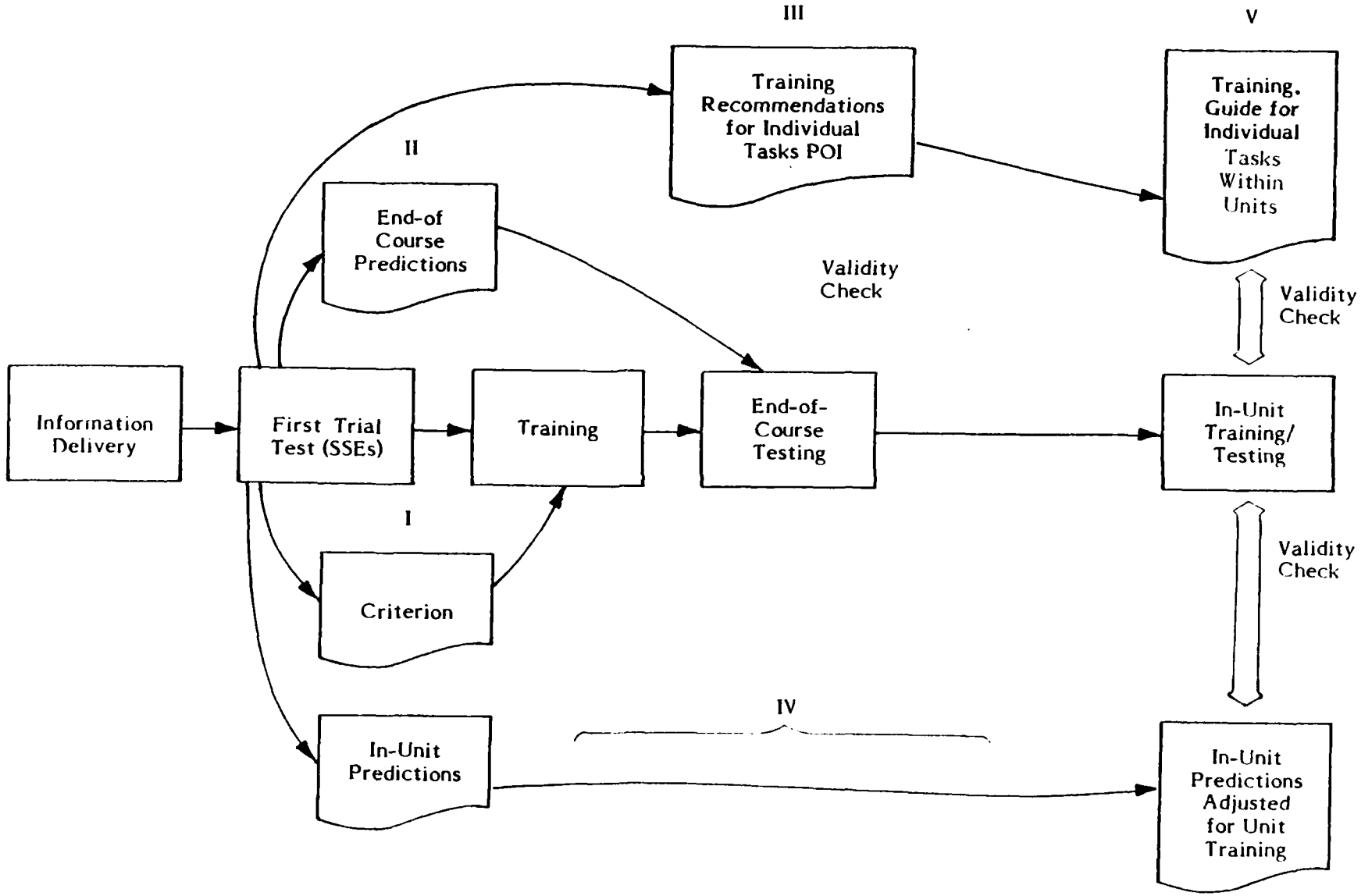
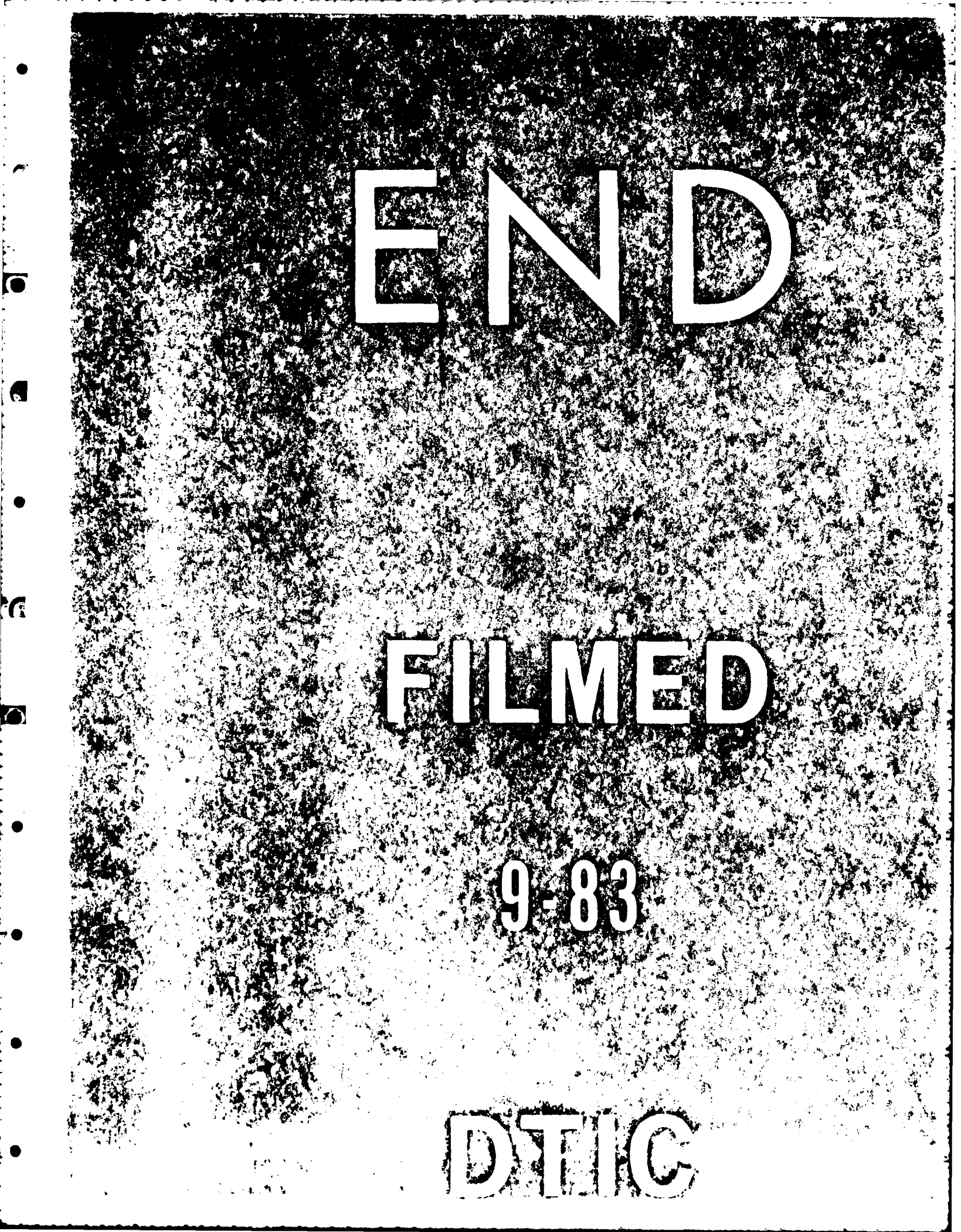



FIGURE 6: STAR©DATA BASE PRODUCTS DEVELOPED IN THIS OPERATIONAL TEST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